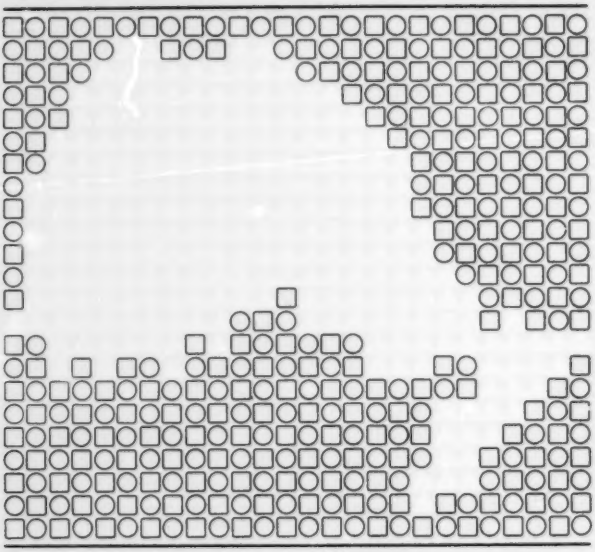
Ontario
Ministry of
Labour

Occupational
Health and Safety
Division

Designated Substances in the Workplace: A Guide to the Isocyanates Regulation



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Designated Substances in the Workplace: A Guide to the Isocyanates Regulation

September 1987

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Introduction

This guide has been prepared to help employers, workers, members of joint health and safety committees, supervisors and occupational health personnel meet the requirements of the designated substance regulation respecting isocyanates in the workplace and understand the responsibilities this regulation places on all participants in the workplace health and safety system.

The advice in this guide is the interpretation, by officials of the Occupational Health and Safety Division, of the Occupational Health and Safety Act (the Act) and regulations.

The advice does not have binding effect but is intended to provide general answers to possible questions asked in the context of a specific situation. It is being used by staff of the ministry to assist in the administration of the isocyanates regulation.

Questions of construction and application will find their ultimate answer given by the courts where a contest ensues as to construction or application of a legislative provision.

The Occupational Health and Safety Division of the Ministry of Labour is responsible for administering the Act. The Regulation respecting Isocyanates, Ontario Regulation 455/83, was filed with the Registrar of Regulations on July 15, 1983. The provisions relating to the assessment came into force on the date of filing; those relating to control measures came into force on October 13, 1983. An amendment to the Schedule, Ontario Regulation 23/87, came into effect on February 21, 1987.

This guide is intended as a supplement to the booklet entitled **Designated Substances in the Workplace: A General Guide to the Regulations** to help employers, workers and members of the joint health and safety committee meet the requirements of the isocyanates regulation. It reviews the health effects of isocyanates, their uses and the forms of workplace exposure. In addition, it provides information on the application of the regulation, exposure limits, the assessment and control program and medical surveillance.

It is important that both this guide and the general guide to the regulations, referred to above, be consulted.

For further information on any aspect of the isocyanates regulation, contact the Inspectorate of the Ministry of Labour at the appropriate district office. Appendix 4 lists the addresses and telephone numbers of the district offices of the ministry.

1. The Hazards of Isocyanates in the Workplace

What Are Isocyanates and How Are They Used?

Isocyanates are a class of chemicals used in the manufacture of certain types of plastics, foams, coatings and other products. An isocyanate is a compound that contains at least one group of atoms consisting of a Nitrogen (N), a Carbon (C) and an Oxygen (O) atom. The isocyanate (-NCO) group reacts very readily with certain other types of molecules, a property responsible for the usefulness of isocyanates in industry. When the isocyanate group reacts with a class of substances called polyalcohols, or polyols, a class of polymers (long, chain-like molecules) called polyurethanes are formed. Another type of polymer made from isocyanates and polyols are polyisocyanurates. These are formed when isocyanate groups combine with each other to form a ring-like molecular structure. This molecular ring causes the polyisocyanurates to be very stable when heated.

Isocyanates may be classified by the number of isocyanate (-NCO) groups contained in each molecule. The monoisocyanates, such as methyl isocyanate and phenyl isocyanate, contain only one isocyanate group per molecule. They are used in the preparation of some drugs and pesticides. The isocyanates used to produce polyurethanes and polyisocyanurates are diisocyanates and polyisocyanates. Diisocyanates contain two isocyanate groups per molecule and polyisocyanates contain three or more isocyanate groups per molecule. The diisocyanates may be referred to as "monomers", which means a single molecule that can be used to build a polymer.

The diisocyanates most commonly used are toluene diisocyanate (TDI), and methylene bisphenyl isocyanate (MDI). TDI is used primarily in the production of flexible foams and soft synthetic rubbers. MDI is used in the production of flexible and rigid foams, hard synthetic rubbers (elastomers) and coatings. Other types of diisocyanates used in industry include isophorone diisocyanate (IPDI), used in coatings, hexamethylene diisocyanate (HDI), used in coatings, leather finishing and foams, and naphthalene diisocyanate (NDI), used to produce elastomers.

Polyisocyanates (also called polymeric isocyanates) are used to make polyurethane coatings, adhesives and specialty printing inks. Polymeric isocyanates are the main constituent of hardeners for automobile body paints. Most commercial polyisocyanate products contain some diisocyanate monomer, often referred to as "residual monomer".

"Blocked" isocyanates have been developed to reduce some of the hazards associated with isocyanates. They are formed by reacting an isocyanate with another chemical so that the -NCO group is "blocked" by another molecular group. While it is blocked, the -NCO group cannot react to form a polymer and does not pose as severe a health hazard as does the unblocked -NCO group. When the blocked isocyanate is heated, the unblocked -NCO group is regenerated.

Depending on the type of isocyanate and the use for which it is intended, isocyanates may be supplied in solid or liquid forms. TDI, HDI and IPDI are colourless to pale yellow liquids, while NDI is a white powder. MDI may sometimes be supplied in solid form as white or yellow flakes, but is usually in the form of a dark brown viscous liquid. Polymeric isocyanates are usually supplied in liquid solvent solution. Characteristics of the most commonly used isocyanates are presented in Table 1. Table 2 lists some of the products made with isocyanate-based polyurethanes and polyisocyanates.

TABLE 1

CHARACTERISTICS, USES AND EXPOSURE HAZARDS OF SOME COMMONLY USED ISOCYANATES

Chemical Name(s)	Abbreviation	Some Trade Names	Physical Appearance	Common Uses	Comments - Exposure Hazard
DIISOCYANATES					
toluene diisocyanate	TDI	Hylene T Mondur TDS Nacconate 100 Niax TDI Voranate T-80	colourless to pale yellow liquid	flexible foams, soft synthetic rubbers, adhesives and sealants, coatings	very volatile - releases vapour readily
methylene bisphenyl isocyanate; also called diphenylmethane diisocyanate	MDI	Multrathane M Nacconate 300 Hylene M Mondur M Isonate 125 M	dark brown viscous liquid; white or yellow flakes	rigid and flexible foams, hard synthetic rubbers, coatings (combined with poly-isocyanates), insulation, packaging, binder for foundry cores	not very volatile, but vapour may be released when heated - e.g. as in foundries; main inhalation hazard from spraying coatings, insulation, etc.

(TABLE 1 Contd.)

Chemical Name(s)	Abbreviation	Some Trade Names	Physical Appearance	Common Uses	Comments - Exposure Hazard
hexamethylene diisocyanate	HDI	Desmodur H	colourless to light tan liquid	coatings - (combined with polyisocyanates), leather finishing, foams, synthetic rubbers, sealants	very volatile - releases vapour readily; may be present as residual monomer in paint hardeners, coatings
isophorone diisocyanate	IPDI	IPH-T-1890	colourless liquid	coatings, synthetic rubbers, leather and textile finishing	less volatile than TDI and HDI; may be present as residual monomer in paint hardeners, coatings
naphthalene diisocyanate	NDI	Desmodur N Mondur 15	white to yellow solid	synthetic rubbers, sealants	dust hazard

(TABLE 1 Contd.)

Chemical Name(s)	Abbreviation	Some Trade Names	Physical Appearance	Common Uses	Comments - Exposure Hazard
POLYISOCYANATES					
polymethylene polyphenyl isocyanate	PMPPI	PAPI Niax AFPI VAN Mondur MR Lupranate M-20	dark amber viscous liquid	foam, insulation, synthetic rubbers, foundry core binders, adhesives and sealants	commercial preparations contain 50% MDI and 50% PMPPI; not very volatile but MDI vapour may be released when heated; main inhalation hazard from spraying coatings, insulation, etc.
aliphatic polyisocyanates		Extra-Cure Dynakote Centari Activator Imron Activator Super Cure Diamont Hardener Delthane Ultra Deltron Catalyst Sunfire Hardener Polasol Hardener	solid in pure form; usually supplied commercially in liquid solutions	paint hardeners	paint hardeners contain some residual monomer (usually HDI or IPDI) which may be released as vapour; the polyisocyanates themselves do not vaporize, but may be inhaled in mist from spray painting

TABLE 2

ISOCYANATE-BASED PRODUCTS

		Type of Isocyanate
1.	Flexible Foams	TDI
-	furniture	MDI
-	seating cushions	Polyisocyanates
-	car seats	
-	airplane seats	
-	foam mattresses	
-	packaging	
-	lining for coats and sleeping bags	
2.	Rigid Foams	MDI
-	foam-core panels	Polyisocyanates
-	furniture and appliance casings	
-	spray-on insulation for buildings, refrigerators, pipes, tanks, and vehicles	
-	packaging for delicate equipment	
3.	Synthetic Rubbers (Elastomers)	
-	soft - e.g. used for printing rollers	TDI
-	hard - e.g. used for roller-skate wheels, automotive parts	MDI NDI Polyisocyanates
4.	Paints, Coatings, Sealants, Adhesives	Polyisocyanates HDI IPDI TDI
5.	Printing Inks	Polyisocyanates
6.	Foundry Core Binders	MDI Polyisocyanates
7.	Textile and Leather Finishing	HDI, TDI
8.	Wire Varnish	TDI

What Are the Health Hazards of Isocyanates?

Due to the high reactivity of the isocyanate (-NCO) group, exposure to isocyanates can result in primary irritation, sensitization and hypersensitivity reactions. The respiratory system, the eyes and the skin are the main areas affected by exposure.

The Respiratory System: There are three different ways in which isocyanates can affect the respiratory system:

1) Isocyanates are severe respiratory tract irritants. At moderately high levels of exposure (about 0.03 to 0.07 parts per million parts air), they can cause symptoms such as cough, sore throat, chest pain and shortness of breath. Depending upon exposure levels and the length of the exposure, these symptoms may appear four to eight hours after the beginning of exposure. Exposure to very high levels of isocyanates can cause chest tightness, bronchitis, severe bronchospasm and fluid in the lungs. Other symptoms may include nausea, vomiting and abdominal pain. Long-term exposure can lead to the development of chronic bronchitis.

2) Exposure to isocyanates over a long period of time may cause a gradual decline in lung function even without the development of symptoms.

3) Isocyanates can cause sensitization in some people. This is a reaction in which the person, after a period of initial exposure to isocyanates, develops an acute allergic response to further exposure. After someone has become sensitized to isocyanates, exposure to even very low levels (e.g. below the exposure limit of 0.005 parts per million) can cause severe breathing difficulties. The early stages of sensitization are often marked by mild chronic respiratory complaints, such as a persistent cold, coughing, shortness of breath and asthmatic bronchitis. Further exposure of sensitized individuals can

produce severe asthmatic attacks. Some individuals experience asthmatic attacks with no prior symptoms. Some sensitized individuals may have asthmatic reactions to types of isocyanates to which they have not previously been exposed.

The Skin: Direct skin contact with isocyanates can cause rashes, blistering and reddening of the skin. In rare cases, repeated skin contact may cause skin sensitization, which can lead to severe skin reactions in response to contact with small amounts of isocyanates.

The Eyes: Exposure to airborne isocyanates can cause the eyes to tear and result in eye irritation and a temporary decrease in sharpness of vision. Isocyanates splashed into the eye can cause severe irritation and possible damage to the cornea (the membrane covering the lens of the eye).

Isocyanates and Cancer

It has not been proven that exposure to isocyanates can lead to an increased risk of cancer in humans. However, recent studies have shown that rats and mice exposed to TDI had an increased rate of cancer. Such a finding indicates that TDI should be considered a suspect carcinogen (cancer-causing agent) unless further research proves otherwise. In addition, studies with bacteria have shown that both TDI and MDI have the ability to cause mutations (changes in the genetic material of cells). Many substances that cause mutations are also carcinogenic; therefore, the possibility exists that exposure to MDI as well as TDI may pose an increased cancer risk.

How Can Workers Be Exposed to Isocyanates?

Workers may be exposed to isocyanates through inhalation or by direct contact.

1. **Inhalation:**

Isocyanates may be inhaled if they are present in the air in the form of a **vapour**, a **mist** or a **dust.**

- A **vapour** is the gaseous form of a substance that has been given off (evaporated) from a liquid or a solid. The amount of isocyanate vapour released into the air in a given time depends on temperature and the volatility of the specific isocyanate used. "Volatility" refers to how rapidly a substance releases vapour at a given temperature. The higher the temperature to which the isocyanate is heated, the more rapidly vapour will be released.
- A **mist** is a suspension of small liquid droplets in the air. Mists are formed in the workplace by operations that involve spraying, such as spray painting or the application of spray-on insulation.
- A **dust** is a suspension of solid particles in air. Some isocyanates, such as MDI, are sometimes supplied in flake or powder form, which can give rise to a dust hazard. Exposure to isocyanate dust may also occur as a result of sawing or scraping uncured polyurethane that still contains some unreacted - NCO groups.

2. **Skin and Eye Contact:**

Isocyanate vapour may cause irritation of the eyes, nose and throat. Liquid isocyanates can cause damage if they come in contact with the skin or eyes. A skin reaction may also result from direct contact with uncured polymers (polymers that contain some unreacted - NCO groups). Isocyanates are not absorbed into the body through the intact skin.

Are Some Isocyanates More Hazardous Than Others?

The relative hazard of different isocyanates and different processes using isocyanates depends on the likelihood that molecules containing unreacted isocyanate groups will become airborne.

- More volatile isocyanates, such as TDI and HDI, are often more hazardous than the less volatile isocyanates, such as MDI or polyisocyanates, because they are more likely to release vapours into the air.
- Even the less volatile isocyanates, such as MDI and polyisocyanates, are hazardous when sprayed because mists containing isocyanate groups become suspended in the air.
- The higher the temperature of an isocyanate, the more rapidly it will release vapour, and the greater hazard it will pose.

Safety and Fire Hazards of Isocyanates

When isocyanates react with water, ammonia, alcohols or strong bases, heat and carbon dioxide gas are released. If such a reaction occurs in a sealed container, the container may explode, releasing isocyanate vapour and other toxic gases. Isocyanates are not considered to be highly combustible. However, in the presence of fire and high heat, they will burn and release toxic gases such as carbon monoxide, nitrogen oxides and hydrogen cyanide. Finished polyurethane products are more combustible than isocyanates and, when burned, can release a number of hazardous substances including benzene, toluene, carbon monoxide, oxides of nitrogen and hydrogen cyanide.

2. The Isocyanates Regulation

Who Is Covered by the Isocyanates Regulation?

The isocyanates regulation applies to all employers and workers at workplaces where isocyanates are produced, used, handled or stored and where a worker is likely to inhale or come in contact with isocyanates. There is, however, one major exception to this application: the regulation does not apply to constructors, employers carrying out construction projects or workers working at construction projects.

Must the Employer Protect Workers Who Are Present in the Workplace but Who Are Not Working Directly for the Employer?

An employer to whom the regulation applies must take every reasonable precaution to protect a worker present in the workplace, even if that worker is not directly employed by the employer. It would be reasonable for the employer to take into account the exposure limit and respiratory protection provisions of the regulation in considering appropriate measures for such employees. The worker must comply with the requirements set out by the employer. These obligations are not applicable to constructors, employers carrying out construction projects or workers on construction projects.

What Are the Allowable Airborne Concentrations of Isocyanates?

The regulation sets out exposure levels for four specific isocyanates. For all other isocyanates it does not mandate exposure limits but requires specific industrial hygiene provisions and protective

equipment. This is because there are no satisfactory methods for analyzing the concentration of polyisocyanates in air.

The regulation sets allowable exposure levels for TDI, MDI, HDI and IPDI. The exposure of a worker to these four isocyanates must not exceed the levels that are specified in the regulation.

Time-Weighted Average Exposure Concentration

The employer must take all necessary measures by means of engineering controls, work practices, and hygiene practices and facilities to ensure that the time-weighted average exposure of a worker to TDI, MDI, HDI or IPDI is reduced to the **lowest practical level**. Pages 7 and 8 of **A General Guide to the Regulations** explain how the lowest practical level for each workplace is determined.

In any case, the time-weighted average exposure of a worker to TDI, MDI, HDI or IPDI must not exceed **0.005 ppm** (parts isocyanate per million parts of air by volume) or 0.2 micromoles isocyanate per cubic metre (m^3) of air. (A mole is a unit of measurement related to the number of molecules of a substance.)

The time-weighted average exposure concentration is calculated on the basis of cumulative weekly exposure (40 hours) and cumulative daily exposure (8 hours), as indicated in the Schedule appended to the regulation.

Maximum Exposure Concentration

The maximum exposure of a worker to TDI, MDI, HDI or IPDI must not exceed **0.02 ppm** or 0.8 micromoles per m^3 of air in any period of time.

What Must the Employer Do to Control Exposure to Isocyanates Other Than TDI, MDI, HDI or IPDI?

If there is potential exposure to any isocyanate other than the four listed above, an employer must adopt and implement all reasonable and practical engineering controls, work practices and hygiene practices to control exposure. The employer must also provide appropriate personal protective equipment to any worker who is likely to inhale or come into contact with these isocyanates. The worker is required to use this equipment.

3. Assessing and Controlling Exposure to Isocyanates

The Assessment

Chapter 2 of **A General Guide to the Regulations** describes how to assess the extent to which workers are exposed to isocyanates and prepare the written assessment report required by the regulation. When carrying out the assessment, the employer should pay particular attention to any process that produces dusts or mists or that involves heat, since heating increases the vaporization rate of isocyanates. Because the interaction of isocyanates with polyols produces heat, the generation of vapours is of particular concern during the manufacture of polyurethane and polyisocyanurate products. Steps in the manufacturing process where exposure to vapours is particularly likely to occur include:

- transfer and dispensing of isocyanates;
- mixing of isocyanates with polyols;
- foam expansion;
- opening of curing ovens and moulds; and
- handling of uncured polyurethane and polyisocyanurate products that may contain residual isocyanates.

Particular attention must also be paid to any process that involves the spraying of isocyanates. For example, installation of some isocyanate-based packaging or insulation utilizes spray guns that mix the isocyanate and polyol components as spraying occurs. Spraying is often performed with paints and coatings to which isocyanate hardeners are added just before application. All these spraying applications generate high concentrations of isocyanate mist.

Heating finished products made from isocyanate-based polymers can also lead to isocyanate exposure. For example, when polyurethane foam is cut with a hot wire, isocyanate vapour may be released.

The assessment should address the following points:

- What materials containing isocyanates are used in the workplace?
- How are isocyanates received into the workplace (e.g. bulk tanker, drums, etc.)?
- How are isocyanates stored?
- What is the vapour pressure of the particular isocyanates used? The higher the vapour pressure the more volatile the isocyanate is. For example, at 25°C, MDI has a vapour pressure of 0.00014 mm Hg (millimetres of mercury), while the more volatile TDI at the same temperature has a vapour pressure of 0.05 mm Hg.
- What are the operating temperatures and pressures of the processes used?
- Are isocyanates used in open or closed processes?
- What local and general ventilation is used?
- Does the process involve heating, cutting or spraying of materials?
- What are the procedures for dealing with spills and splashes?
- What personal protective equipment is available and used?
- Is there potential for leaks of isocyanates around pumps, valves, flanges and connections? What maintenance procedures are in place to prevent such leaks from occurring?
- What procedures are used for regular cleaning and maintenance of equipment used for isocyanate operations?
- What are the disposal procedures for materials contaminated by isocyanates?
- Do any workers experience respiratory or eye irritation or any persistent or recurring respiratory symptoms?

As part of the assessment, Material Safety Data Sheets for all isocyanates used should be obtained and reviewed. Suppliers should also be requested to provide technical literature on safety precautions to be observed.

Table 3 presents a list of some types of work that may involve exposure to isocyanates. Workplaces where isocyanates are used in any of these applications should be carefully assessed for isocyanate exposure.

The assessment may reach one of four possible conclusions, as described on pages 26-27 of **A General Guide to the Regulations.** The conclusion that is reached will determine whether or not an isocyanates control program is necessary.

The Control Program

If the assessment concludes that a control program is required, then a written isocyanates control program must be prepared.

The control program must include provisions for engineering controls, work practices, hygiene practices and facilities, air monitoring, record keeping and medical surveillance. In addition, the regulation requires a training program for supervisors and workers on the health effects of isocyanates and the provisions of the control program.

TABLE 3

TYPES OF WORK THAT MAY INVOLVE EXPOSURE TO ISOCYANATES

- polyurethane production
- abrasion-resistant rubber manufacture
- polyurethane paint, varnish and coating manufacture
- spray painting
- insulation production and installation
- spraying of elastomers (coatings)
- packaging operations
- rigid polyurethane moulding
- adhesives production and use
- wire coating production
- soldering polyurethane-coated wire
- aircraft construction and maintenance
- strip welding
- upholstery manufacture
- textile and leather treatment
- splicing telephone cables
- foundry core manufacture
- printing

Engineering Controls

If an isocyanate control program is required, it must include engineering controls to reduce the exposure of workers to isocyanates. These controls can be grouped into the categories outlined in Chapter 4 of **A General Guide to the Regulations.** Examples of appropriate controls for some types of isocyanate operations are indicated on the **process flow sheets** included in Appendix 1 of this guide.

Product Substitution

Where possible, isocyanates should be replaced by less toxic materials. If this can not be done, it may be possible to reduce worker exposure to isocyanates by replacing a volatile isocyanate such as TDI or HDI with a less volatile isocyanate such as MDI or a polymeric isocyanate. The use of blocked isocyanates can also help to reduce exposure.

Process Controls

Where possible, use cold rather than hot processes to minimize the generation of isocyanate vapours. For example, avoid hot wire cutting of polyurethane foam. Maintain temperature control when mixing isocyanates with polyols to produce polyurethane. If possible, use low rather than high operating pressures.

Alarms or automatic shut-off switches can be installed to warn of high pressure, high temperature, pump failure, low or high levels and ventilation system failure. Use closed-loop rather than one-ended quality control sampling stations.

Provide safeguards to ensure that isocyanate and polyol components are mixed in the correct ratio. Unique couplings for isocyanate and polyol component lines can eliminate the possibility of accidentally

switching the lines, which can cause a severe health and safety hazard.

Substitute brush painting or dipping for spray painting, wherever possible. Where spraying must be performed, the use of an airless type of spraying apparatus will generate less airborne mist than the air-using type. Lowering the spraying pressure will reduce the amount of mist produced.

Automating a process can also help to reduce exposure and prevent spills and accidents. For example, transfer and dispensing operations should be performed with a pump or vacuum technique. Mixing should be performed automatically in sealed vessels, rather than manually.

Enclosure/Isolation

Dispensing, mixing, moulding and curing operations should be performed in enclosed systems. Pumps, valves and seals must be well-maintained to prevent leaks. Mechanical seals are more effective than packed seals in controlling emissions. Double mechanical seals are more effective than single mechanical seals. Closed systems containing volatile isocyanates such as TDI and HDI must be vented by an exhaust system to the outside.

The spraying of isocyanate-based coatings or foam should be conducted in mechanically ventilated spray booths by workers using protective equipment. Steps must also be taken to prevent the exposure of workers not involved in the operation. Barriers should be used to prevent the spread of isocyanate vapours to other areas of the plant. Work areas where isocyanate-containing products are sprayed should be maintained under negative pressure to prevent the spread of isocyanate vapour or mist to other work areas.

Ventilation

Even a well-enclosed system will have points at which isocyanate vapours may escape into the workplace air. Therefore, good local exhaust ventilation is important to control exposure, especially for volatile isocyanates such as TDI or HDI, or for operations that involve heating or spraying of any isocyanates. Ventilation should always be provided at weighing, mixing, dispensing and foam expanding points, and at curing ovens, mould openings, spray operations and storage areas. When an enclosed system is opened for cleaning or maintenance, local exhaust ventilation should be used.

Application of isocyanate-based insulation and packing material must always be conducted under well-ventilated conditions. Local exhaust ventilation is usually provided at the pouring hole when insulation is pumped into the cavities of products such as refrigerator shells, trailers and automobiles.

Contaminated air that is vented to the outside environment must meet the limits on isocyanate emissions set under the Environmental Protection Act, R.S.O. 1980, c.141. For details, contact the Ontario Ministry of the Environment.

In addition to local exhaust ventilation, good general ventilation is required to ensure that the concentration of airborne isocyanates throughout the workplace remains low.

Work Practices, Hygiene Practices and Housekeeping

A written work procedure is important to ensure that safety precautions and proper work practices are followed. Signs should be posted where isocyanates are used, and containers should be labelled with the name of the isocyanate and the precautions for safe use. Pipes used to transfer isocyanates should also be labelled and the direction of flow identified.

Equipment used in the handling of isocyanates should be decontaminated and cleaned promptly after use. It is important to ensure that mixing heads and spray gun nozzles are flushed after use if they are not of the self-cleaning type. Otherwise, the head may become plugged, resulting in pressure build-up and possible rupture.

Eating, drinking, and smoking should be forbidden in areas where exposure to isocyanates is possible. Skin contact with isocyanates must be avoided.

A regular program of equipment maintenance is necessary to reduce the likelihood of isocyanate leaks from pumps, valves, seals and connections. The ventilation system must also be well-maintained. Special attention must be paid to maintaining equipment in which isocyanates are kept or used under pressure. Isocyanates can cause rubber or plastic to become brittle and crack; therefore, rubber or plastic hoses used for pumping are in danger of rupturing and should be inspected frequently.

Appropriate personal protective equipment must be worn during cleaning and maintenance of equipment.

Storage of Isocyanates

Areas where isocyanates are stored should be well-ventilated and maintained at temperatures below 25°C. Storage tanks should be vented to the outside. Isocyanate feedstock should be stored in sealed containers. However, containers of contaminated isocyanates should never be sealed without providing a means to vent any gases that may be formed. Otherwise, an explosion may occur.

Care must be taken that damaged or leaking containers of isocyanates do not cause an exposure hazard. Leaking containers should be removed to the outdoors or to an isolated, well-ventilated area, and the contents transferred to another receptacle. Isocyanates should not be stored near acids, bases, alcohols or

amines. Moisture must be prevented from entering storage containers as the reaction of water with isocyanates forms carbon dioxide gas, which can cause the container to explode. If a container appears to be under pressure, all non-essential staff should be evacuated from the area and emergency measures taken to alleviate the pressure in the container. Details of appropriate procedures are available from suppliers of isocyanates.

Isocyanates, especially TDI, can freeze in cold weather. If a container of isocyanates requires thawing, it should be stored in a warm atmosphere under well-ventilated conditions. It is dangerous to apply direct heat to thaw a container of isocyanates.

Dispensing isocyanates from drums or tanks can be hazardous. Workers must wear appropriate protective equipment and follow supplier's instructions.

Clean-Up of Spills

All spills of isocyanates must be cleaned up immediately. Decontaminants are available, in solid or liquid form, that react with isocyanates to form more stable compounds that can be safely disposed of. For example, one solid decontaminant mixture can be prepared from 60 parts by weight Fuller's earth, sawdust or vermiculite, 25 parts by weight 30 per cent ammonia and 15 parts by weight isopropyl alcohol. A solution of eight parts water, one part isopropyl alcohol and one part ammonia can be used as a liquid decontaminant for cleaning surface areas. Clothing can be decontaminated with a solution of nine parts water, one part ammonia and some liquid detergent.

Ammonia solutions are not effective decontaminants if the isocyanate spill freezes. In freezing weather, a decontaminant mixture of 50 per cent isopropyl alcohol and 50 per cent 1,1,1-trichloroethane can be used. Extreme caution should be exercised, however, as this mixture is flammable.

Solid decontaminant can be spread on a spill to absorb and neutralize the isocyanates. It should be allowed to react for at least 10 minutes and then it should be swept up and placed in an uncovered container with more decontaminant. The container should be kept uncovered in an isolated area for 24 hours and then disposed of in a manner acceptable to the Ministry of the Environment. After sweeping up the solid decontaminant, the area of the spill should be washed with liquid decontaminant. Very small spills can be wiped up with rags, and the area treated with liquid decontaminant. Rags and other clean-up equipment must be disposed of in a proper manner. Further details for treating spills are available from suppliers of isocyanates. Decontaminants should be stored in a readily accessible location wherever isocyanates are used.

Workers cleaning up isocyanate spills must wear appropriate protective equipment. All workers not involved in the clean-up should be evacuated from the area.

An evacuation plan and emergency procedure must be developed to deal with major spills of isocyanates. One staff member on each shift should be designated as responsible for carrying out emergency procedures. In the event of a major spill, notify the nearest district office of the Ministry of Labour immediately. (See list of offices in Appendix 4.)

Disposal

Before empty isocyanate containers are disposed of, they should be treated with water or decontaminant to neutralize the isocyanate residue. However, never seal the container while this reaction is taking place—an explosion may result.

Waste isocyanates should be reacted with decontaminant before disposal, according to supplier's instructions. Disposal of isocyanate-

contaminated waste must be in accordance with Ministry of the Environment requirements.

Safety Facilities and Protective Equipment

Protective clothing, including chemical safety goggles or face shield, rubber gloves and coveralls, should be worn by workers handling isocyanates. Because isocyanates can cause rubber to become brittle and crack, care must be taken to replace damaged protective equipment.

Any clothing or protective equipment that becomes contaminated with isocyanates should be decontaminated before it is reused. A solution of nine parts water, one part ammonia and some liquid detergent can be used for soaking contaminated clothing. The employer must take responsibility for cleaning contaminated clothing and for ensuring that laundry workers are aware of the hazards of cleaning isocyanate-contaminated clothing.

Emergency protective equipment should be readily available for use in the event of spills. This should include respirators, long-sleeved impervious gloves, full waterproof clothing, rubber boots and head protection.

When spraying of isocyanate-based coatings or insulation is conducted outdoors, the operator and anyone working within 3 metres (10 feet) of the operation should wear full protective clothing and respiratory protective equipment.

First aid procedures for dealing with splashes and accidental ingestion of isocyanates should be posted in an accessible location. (See Appendix 2). Safety showers and eyewash fountains must be readily accessible wherever isocyanates are used.

Respiratory Protection

The **Code for Respiratory Equipment for Isocyanates**, which is referenced by the regulation, specifies the type of respirator required at different exposure concentrations. Use of respirators should conform to the practices advised in Chapter 5 of **A General Guide to the Regulations.**

The Type of Respirator Required

The respiratory equipment provided by an employer and used by a worker must meet or exceed the following requirements:

Airborne Concentration (Isocyanate vapour and particulates)	Type of Respirator Required
Less than or equal to 0.25 ppm or 10 μmol/m^3	Positive pressure supplied-air respirator with full facepiece or hood or self-contained breathing apparatus with full facepiece.
Greater than 0.25 ppm or 10 μmol/m^3	A NIOSH Type C supplied-air respirator operated in pressure demand or other positive pressure or continuous flow mode, or a self-contained breathing apparatus with a full facepiece operated in pressure demand.
Escape	Any escape self-contained breathing apparatus with full facepiece operated in pressure demand.

Notes: 1. Vapours can be defined as the gaseous form of a substance that is normally either a liquid or a solid at ordinary temperatures and pressures.

2. Respirators need not be worn if the levels of isocyanates in air are less than 0.005 ppm. However, if the worker wishes to use a respirator below this level, the organic vapour/particulate air purifying respirator (NIOSH/MESA T23C) can be used.

3. Supplied air respirator does not include a powered air purifying respirator.

Dust masks, gas masks or other non-powered air purifying respirators must never be used where levels of airborne isocyanates may exceed 0.005 ppm or 0.2 micromoles per m^3. Because there are no accepted methods for determining airborne levels of polymeric isocyanates, workers exposed to polymeric isocyanates must wear a NIOSH Type C supplied-air respirator operated in pressure demand or other positive pressure or continuous flow mode, or a self-contained breathing apparatus with a full facepiece operated in pressure demand.

Caution must be exercised to ensure that air supplied to respirators is adequate and free from contamination. If compressed air is used, it must meet the appropriate CSA (Canadian Standards Association) standards, as specified in the Respirator Code. If another air supply method, such as blowers, is used, the control program should include provisions for checking that the air flow remains sufficient and that the air supplied to the respirator is not contaminated.

Air Monitoring

Chapter 6 of **A General Guide to the Regulations** describes how to conduct air monitoring for exposure to designated substances. The **Code for Measuring Airborne Isocyanates**, referenced by the regulation, must be followed when conducting monitoring to determine the personal exposure of workers to diisocyanates and to ensure compliance with the exposure limits. This requirement is

subject to section 18 of the regulation, which allows deviation from this Code as long as the employer can demonstrate that alternative methods used are at least as accurate and precise, and provide at least as much protection, as those set out in the Code. Information on equivalency of alternative sampling and analysis methods can be obtained from the Occupational Health Laboratory of the Ministry of Labour, listed in Appendix 4. Because there is no satisfactory method for analysing the airborne concentration of polymeric isocyanates, the control program need not include air monitoring if polymeric isocyanates are used.

While the employer must meet the requirements of the Code, it may also be desirable to use a measurement technique that does not require laboratory analysis as a routine check that leaks are not occurring and that controls are working effectively. Dry tape monitors and colorimetric detector tubes are available for testing levels of isocyanates. Also available are continuous monitoring instruments that sound an alarm when the concentration of isocyanates exceeds a given level. As the odour threshold (the concentration at which a substance can be smelled) of isocyanates is about 0.4 ppm, well above the prescribed exposure limits, it may not be apparent that levels are too high unless monitoring is performed.

Monitoring should be conducted after clean-up of isocyanate spills to make sure that decontamination is complete. It should also be conducted regularly for operations involving heating or spraying isocyanates.

Training

The isocyanates regulation requires that the control program include provisions for a training program for all supervisors and workers affected by the isocyanates control program. Topics that should be covered in the training program include:

- health effects and symptoms of exposure to isocyanates;
- measures and procedures required under the isocyanates control program;
- how isocyanates are used in the specific workplace and operations that may result in exposure;
- engineering controls in place to prevent exposure to isocyanates and ways of determining whether these controls are operating properly;
- work practices, housekeeping measures and hygiene practices that must be observed to control exposure to isocyanates;
- emergency procedures, including spill clean-up and first aid;
- proper use and maintenance of protective clothing and respirators; and
- details of the medical surveillance program and the purpose of clinical tests used by the examining physician.

4. Medical Surveillance for Exposure to Isocyanates

The isocyanates regulation requires that the control program provide for a medical surveillance program, which must include:

- pre-employment, pre-placement and periodic medical examinations;
- clinical tests;
- health education;
- record keeping.

The medical surveillance program is outlined in the **Code for Medical Surveillance for Isocyanates Exposed Workers** and is designed to protect the health of workers through the education of all staff to the health hazards associated with isocyanate exposure.

The objectives of the medical surveillance program are both preventive and remedial. Medical conditions that may be aggravated by exposure to isocyanates should be detected at the pre-placement and periodic examinations. By providing a regular check on workers exposed to isocyanates to detect adverse health effects, the examining physician can alert the employer and the joint health and safety committee to exposure problems in the workplace that might otherwise go unrecognized. This should ensure that remedial steps will be taken. Health education for workers on the health effects of isocyanates and the manner in which exposure can be limited are also preventive functions of the program.

Section 3 of the Code explains what the physician should look for at the pre-placement and periodic medical examinations. Medical

records kept by the physician should include the information listed in section 6 of the Code.

Questionnaire

The Code specifies that a screening questionnaire must be administered to workers prior to employment and periodically every six months. The purpose of this questionnaire is to determine:

a) history of frequency and duration of exposure to isocyanates since the previous examination; and

b) signs and symptoms that may be an early indication of isocyanate sensitivity, such as irritation of the eyes, nose and throat, skin changes, coughing, wheezing or shortness of breath.

The results of the questionnaire may be used by the examining physician in deciding whether, and how frequently, to conduct clinical tests. Regardless of the findings, the lung function tests are to be performed at least once every two years.

Clinical Tests

Section 4 of the Code explains the clinical tests that are used in assessing the worker's exposure to isocyanates and fitness for continued exposure. Pulmonary (lung) function tests are to be performed if indicated by the questionnaire and at least once every two years. These tests help to determine whether there is any obstruction of the airways or decrease in the ability of the lungs to expand. Lung function tests required by the Code include the following measurements:

FVC (Forced Vital Capacity):	This measures how much air the person can exhale in one breath after inhaling fully.
FEV_1 (Forced Expiratory Volume in one second):	This measures how much air the person exhales in one second after inhaling fully.
PEF 25 per cent - 75 per cent (Forced Expiratory Flow):	This measures how fast the air is breathed out during the middle half of the expired breath.

Subsection 4(1) of the Code provides a reference for standards for the calibration of instruments used to perform these tests and explains when during the work week they should be performed.

Chest x-rays may be requested by the examining physician if indicated by the results of the questionnaire and lung function tests.

The testing facilities used for x-rays and lung function tests must meet the quality requirements of the Occupational Health Branch of the Ministry of Labour.

Action Levels

If the lung function tests show a 15 per cent decline in FEV_1 or FVC or another significant change since the previous test, the test should be repeated for confirmation. If the results are confirmed, the worker's suitability for exposure to isocyanates must be reviewed, and the worker must be referred for further medical investigation.

If the worker shows evidence of reaction to isocyanates, the examining physician must refer the worker for further assessment. If the physician concludes from this assessment that the worker is fit with limitations or unfit for exposure to isocyanates, he or she

must so advise the employer and the worker, in accordance with the requirements specified in section 17 of the regulation.

The physician must also communicate this advice confidentially and in writing to the joint committee. Section 4(3)(c) of the Code provides some guidance for the physician on when it may be appropriate to conclude that a worker is unfit or fit with limitations for isocyanates exposure.

The Examining Physician

The isocyanates regulation does not stipulate who shall be the examining physician, thus allowing the worker to select the doctor of his or her choice. As a result, the examining doctor may be the company doctor, a private consultant with whom the employer contracts services, a physician on the staff of a clinic or the personal physician of the worker. Every examining physician must know the **Code for Medical Surveillance** and his or her responsibilities.

Where there is more than one examining physician, a physician should be appointed in a co-ordinating role. The role of the co-ordinating physician, who should be selected jointly by the employer and the joint health and safety committee, should be to standardize examination and test procedures, maintain medical records and identify any trends in examinations and test results.

Physician's Reporting Protocol

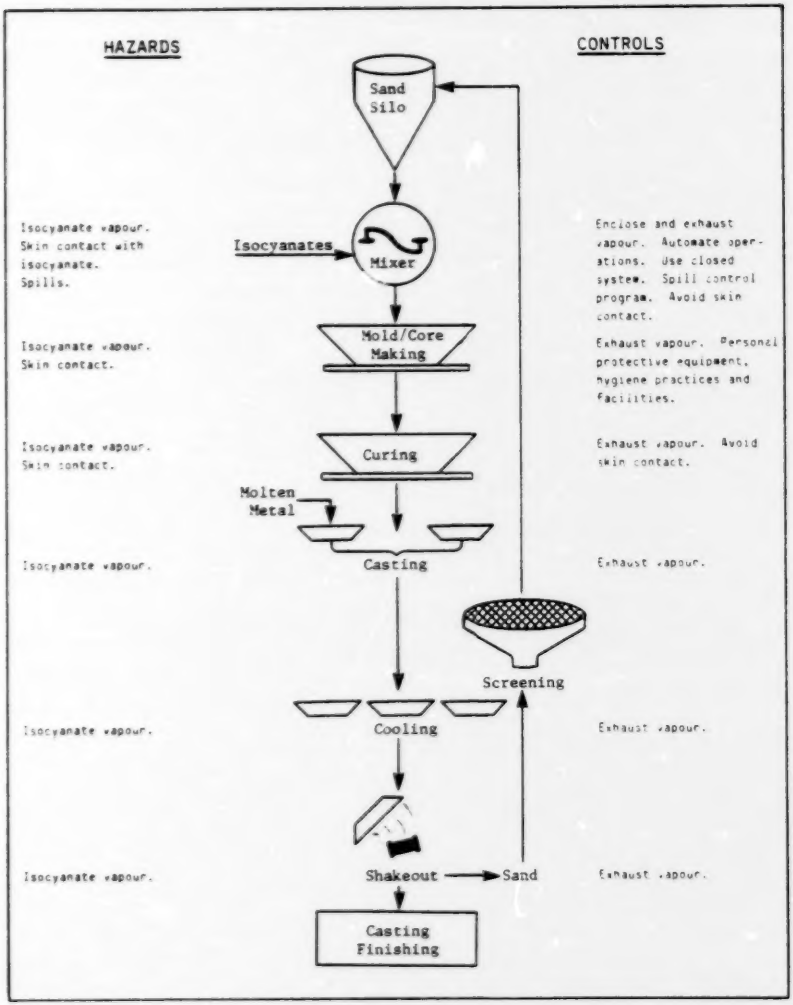
The regulation requires the examining physician to advise the employer and the worker whether the worker is fit, fit with limitations or unfit for exposure to isocyanates. This determination is a professional judgement based on the results of medical examinations and clinical tests. **The physician must give this opinion without disclosing to the employer the results of the examinations or tests.**

If a physician determines that a worker is unfit or fit with limitations for exposure to isocyanates as a result of exposure to isocyanates, he or she must also communicate this advice in writing to the joint committee. In doing so, the physician must give his or her opinion on how the committee should interpret this advice. The committee must receive this advice on a confidential basis. If the physician has advised the employer that a worker is fit with limitations or unfit, he or she must also report this information to the Chief Physician of the Occupational Health Medical Service of the Ministry of Labour. These requirements are specified in subsections 17(1), 17(3) and 17(5) of the regulation.

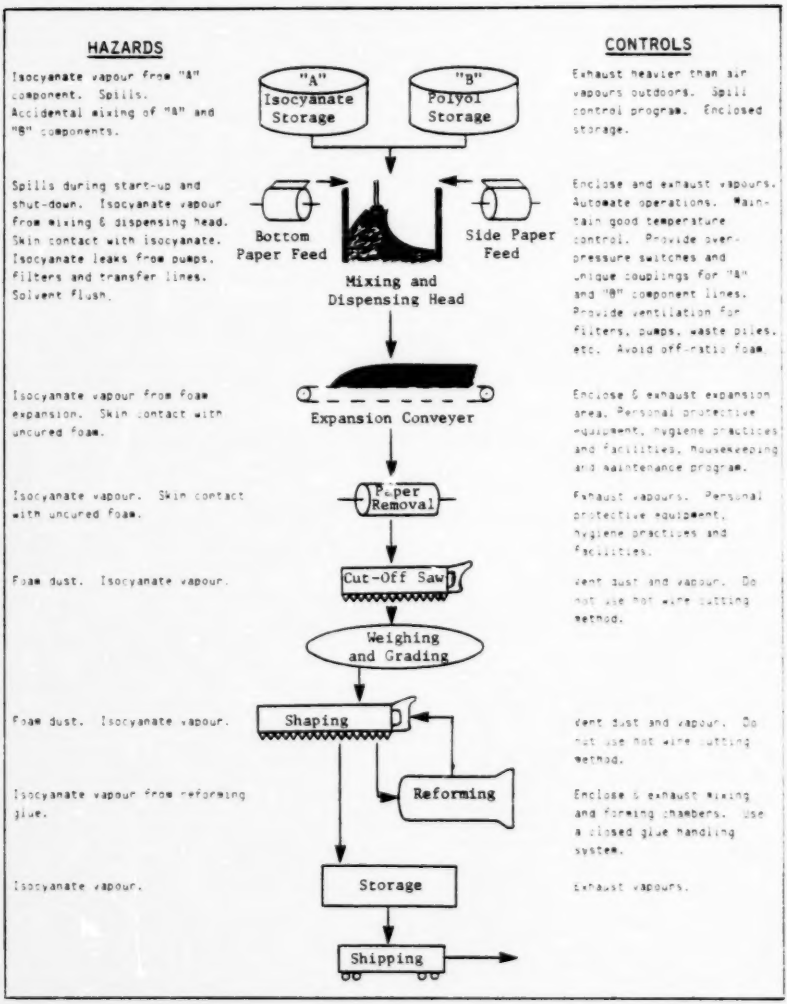
5. Appendices

Appendix I — Process Flow Sheets for Selected Operations Involving Isocyanates

PROCESS FLOW SHEET FOR NO-BAKE FOUNDRY CORES AND MOULDS ISOCYANATES - MOSTLY MDI

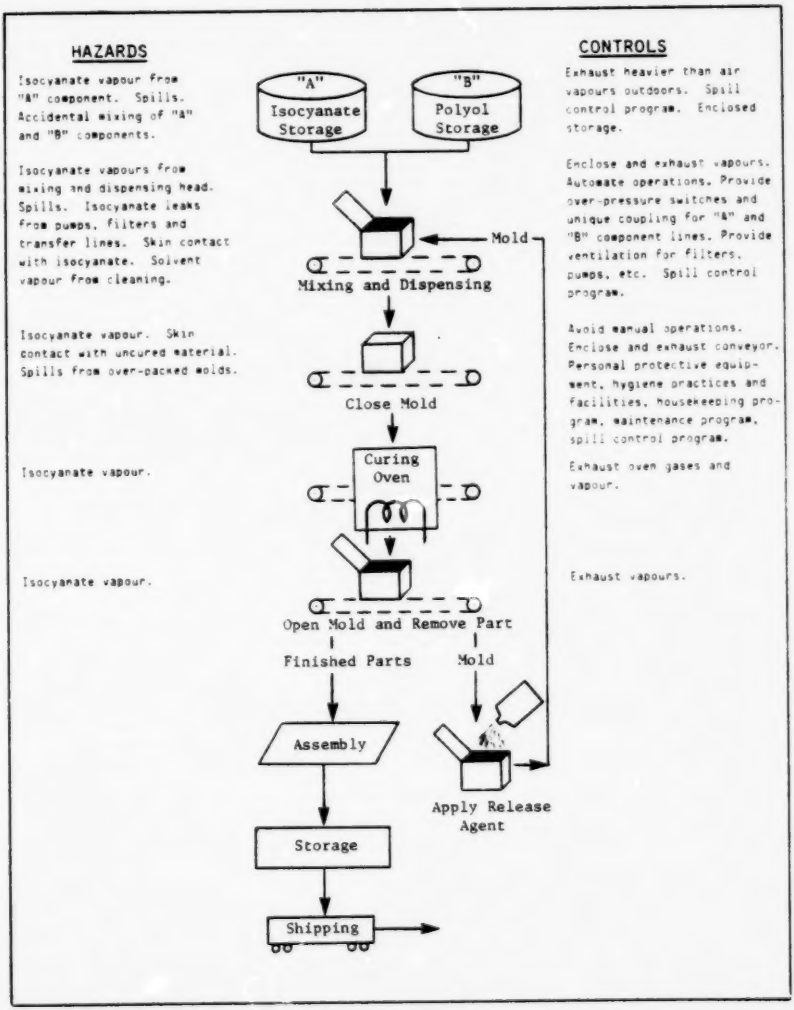


PROCESS FLOW SHEET FOR POLYURETHANE FOAM MANUFACTURE ISOCYANATES - MOSTLY TDI AND MDI


HAZARDS
CONTROLS
Isocyanate vapour from "A" component. Spills. Accidental mixing of "A" and "B" components.
"A" Isocyanate Storage
"B" Polyol Storage
Exhaust heavier than air vapours outdoors. Spill control program. Enclosed storage.
Spills during start-up and shut-down. Isocyanate vapour from mixing & dispensing head. Skin contact with isocyanate. Isocyanate leaks from pumps, filters and transfer lines. Solvent flush.
Bottom Paper Feed
Side Paper Feed
Mixing and Dispensing Head
Enclose and exhaust vapours. Automate operations. Maintain good temperature control. Provide over-pressure switches and unique couplings for "A" and "B" component lines. Provide ventilation for filters, pumps, waste piles, etc. Avoid off-ratio foam.
Isocyanate vapour from foam expansion. Skin contact with uncured foam.
Expansion Conveyer
Enclose & exhaust expansion area. Personal protective equipment, hygiene practices and facilities, housekeeping and maintenance program.
Isocyanate vapour. Skin contact with uncured foam.
Paper Removal
Exhaust vapours. Personal protective equipment, hygiene practices and facilities.
Foam dust. Isocyanate vapour.
Cut-Off Saw
vent dust and vapour. Do not use hot wire cutting method.
Weighing and Grading
Foam dust. Isocyanate vapour.
Shaping
vent dust and vapour. Do not use hot wire cutting method.
Isocyanate vapour from reforming glue.
Reforming
Enclose & exhaust mixing and forming chambers. Use a closed glue handling system.
Isocyanate vapour.
Storage
exhaust vapours.
Shipping

PROCESS FLOW SHEET FOR POLYURETHANE MOULDING

ISOCYANATES - MOSTLY TDI AND MDI


HAZARDS
Isocyanate vapour from "A" component. Spills. Accidental mixing of "A" and "B" components.
Isocyanate vapours from mixing and dispensing head. Spills. Isocyanate leaks from pumps, filters and transfer lines. Skin contact with isocyanate. Solvent vapour from cleaning.
Isocyanate vapour. Skin contact with uncured material. Spills from over-packed molds.
Isocyanate vapour.
Isocyanate vapour.
"A" Isocyanate Storage
"B" Polyol Storage
Mold
Mixing and Dispensing
Close Mold
Curing Oven
Open Mold and Remove Part
Finished Parts
Mold
Assembly
Apply Release Agent
Storage
Shipping
CONTROLS
Exhaust heavier than air vapours outdoors. Spill control program. Enclosed storage.
Enclose and exhaust vapours. Automate operations. Provide over-pressure switches and unique coupling for "A" and "B" component lines. Provide ventilation for filters, pumps, etc. Spill control program.
Avoid manual operations. Enclose and exhaust conveyor. Personal protective equipment, hygiene practices and facilities, housekeeping program, maintenance program, spill control program.
Exhaust oven gases and vapour.
Exhaust vapours.

Appendix 2 — Data Sheets for Inspectors

DIPHENYLMETHANE DIISOCYANATE

DATA SHEET FOR INSPECTORS

DIPHENYLMETHANE DIISOCYANATE*

CAS. REG. NO. 101-68-8

OTHER NAMES

MDI

4,4'-Diphenylmethane diisocyanate

Methylenebis(phenylisocyanate)

Methylene diphenylisocyanate

May be present as a monomer in some polymeric products such as PAPI (Polymethylene polyphenylisocyanate).

TRADE NAMES

Multrathane M, Naccanate 300, Vilrathane

POTENTIAL EXPOSURE

USES: Generally used to produce polyurethane foams, elastomers and coatings

OCCUPATION(S):

Adhesive workers
Insulation workers
Diisocyanate resin workers
Lacquer workers
Organic chemical synthesizers
Paint sprayers
Polyurethane makers
Refrigerator appliance workers
Rubber workers
Ship builders
Textile processors
Wire-coating workers

LEAKS, SPILLS AND DISPOSAL

Prepare a written plan in advance for handling emergencies.

All leaks and spills must receive prompt attention.

For major spills or spills in confined areas, evacuate non-essential personnel and adequately ventilate. Notify Ministry of the Environment (MOE) of major spills.

Wear suitable respiratory equipment and protective clothing (see safety equipment section).

Clean up all spills. Minor liquid spills can be picked up with vermiculite or dry sand.

Place contaminated materials in closed, steel containers for disposal via MOE approved disposal method.

Neutralizing chemicals should be available.

NEUTRALIZING CHEMICALS: There are several solutions available to neutralize MDI; for further information contact the supplier.

EXPOSURE LIMITS (See section 4 of the Regulation respecting Isocyanates)

TWAE: 0.005 ppm, 0.2 micromoles/m^3 (0.05 mg/m^3)

MAXIMUM EXPOSURE CONCENTRATION: 0.02 ppm, 0.8 micromoles/m^3

Notes: 1) All necessary measures shall be taken to reduce worker exposure to MDI to the lowest practical level and in any case shall not exceed 0.02 ppm or 0.8 micromoles/m^3.

2) Details of the methods for air sampling and analysis for MDI are given in the Code for Measuring Airborne Isocyanates appended to the Regulation respecting Isocyanates.

PROPERTIES

FORMULA: $CH_2(C_6H_4NCO)_2$

DESCRIPTION: White to pale yellow solid in pure form; in commercial grades MDI appears as a viscous, dark brown liquid

Odour: Slight musty odour may be present

Odour Threshold: 0.4 ppm (danger: well-above maximum exposure concentration)

SPECIFIC GRAVITY (20°C): 1.2 (solid)

BOILING POINT: Not applicable (polymerizes at 232°C)

MELTING POINT: 38°C

VAPOUR PRESSURE (100°C): 1.7 Pa

VAPOUR DENSITY (Air = 1): 8.6

SOLUBILITY: Soluble in aromatic hydrocarbons, nitrobenzene; acetone, ethers and esters; reacts with water

FIRE AND EXPLOSION

MDI will burn in the presence of fire or a high heat source sufficient to cause vaporization.

EXTINGUISHING MEDIA: Dry chemical powder or carbon dioxide extinguishers, or halons, large amounts of water or foam (MDI reacts with water or water-based foam)

FLASH POINT (open cup): 196°C

HAZARDOUS DECOMPOSITION PRODUCTS: At high temperatures or under fire conditions MDI generates irritating and hazardous vapours and toxic gases (e.g., carbon monoxide, hydrogen cyanide and nitrogen oxides).

STORAGE

Store in a cool, dry, well ventilated area away from acids, bases, amines and alcohols. Tanks and drums should be made from good quality carbon steel, protected from heat and physical damage and inspected for leaks or physical damage regularly.

INCOMPATIBLE WITH: Water, ammonia, amines, alcohols, acids and bases.

LABELLING MUST BE ADEQUATE: Sufficient to identify the major safety hazard and should be consistent with the provincial Dangerous Goods Transportation Act requirements.

*ISOCYANATES ARE DESIGNATED SUBSTANCES
ONTARIO REGULATION 455/83

DIPHENYLMETHANE DIISOCYANATE

(cont'd.)

DIPHENYLMETHANE DIISOCYANATE
CAS. REG. NO. 101-68-8

SAFETY PRACTICES

Keep containers closed as much as possible.

Keep from open flames, heat sources and contact with amines, alcohols, acids, bases and water.

Do not eat, drink or smoke in areas of use.

Do practice good hygiene.

All safety equipment should be kept clean, be regularly inspected and properly maintained.

Remove contaminated work clothing.

VENTILATION:

Operations and processes should be enclosed wherever possible.

Adequate ventilation should be provided in all areas of use.

Respirators should be available in the area of use.

REPAIRS AND MAINTENANCE:

Inform workers of potential hazards of exposure.

Wear suitable protective clothing and respiratory equipment especially in confined spaces (see safety equipment section).

SAFETY EQUIPMENT

Safety glasses with side shields, rubber or poly-vinyl chloride (PVC) boots and gloves, and heavy cotton coveralls. If splashes or aerosol contact is likely a rubber or PVC apron should be worn in addition to an appropriate respirator.

Eyes washes and chemical safety showers should be available in areas of use.

RESPIRATORS: (See section 4(7) of the Regulation respecting Isocyanates and the Code for Respiratory Equipment for Isocyanates appended to the Regulation)

CONC. (ppm)	TYPE
Less than or equal to 0.25 ppm	Positive pressure supplied-air respirator with full facepiece or hood or self-contained breathing apparatus with full facepiece.
Greater than 0.25 ppm	A NIOSH Type C supplied-air respirator operated in pressure demand or continous flow mode or self-contained breathing apparatus with a full facepiece operated in pressure demand.
Escape:	Any self-contained breathing apparatus with full facepiece operated in pressure demand.

NOTES: 1. Respirators must not be a substitute for engineering controls (e.g., adequate ventilation).

2. Supplied-air respirator does not include a powered air purifying respirator.

HEALTH EFFECTS–PROTECTION–FIRST AID

EXPOSURE	SYMPTOMS	PROTECTION	FIRST AID
EYES:	Irritation	Goggles, eyewash facilities available	Immediately flush with water and contact a physician.
SKIN:	Irritation	Gloves, protective clothing (see safety equipment section) Chemical safety shower	Remove contaminated clothing. Wash with water and soap or isopropanol.
INHALATION:	Respiratory and mucous membrane irritation, nausea, vomiting, abdominal pain, coughing, choking, occasionally a full asthmatic attack. Symptoms may occur some time after exposure.	Enclosure, ventilation, respirator (see safety equipment section)	Remove to fresh air. Contact physician. Oxygen may be administered. If breathing has ceased apply artificial respiration.
INGESTION:	Sore throat, abdominal pain, diarrhea	No food or drink in area of use, good hygiene practices	If victim is conscious, give water to drink. Then give activated charcoal in water slurry (1 g activated charcoal per kg body weight). Contact physician.

LONG TERM: Repeated exposure may lead to sensitization and/or reduced pulmonary function.

Note: Where an isocyanate control program exists, medical surveillance of isocyanate exposed workers is required. Details of medical surveillance requirements are given in the Code for Medical Surveillance of Isocyanate Exposed Workers appended to the Regulation respecting Isocyanates.

ADDITIONAL INFORMATION

This data sheet is intended to impart basic information only. If additional information or specific references concerning Diphenylmethane Diisocyanate are required contact your local field office of the Occupational Health Branch.

REV. 06/87

HEXAMETHYLENE DIISOCYANATE

DATA SHEET FOR INSPECTORS

HEXAMETHYLENE DIISOCYANATE*

CAS. REG. NO. 822-06-0

OTHER NAMES

HDI

HMDI

Hexamethylene-1,6-diisocyanate

1,6-Hexamethylene diisocyanate

1,6-Diisocyanatohexane

1,6-Hexanediol diisocyanate

TRADE NAMES

Desmodur H

Note: Isocyanate prepolymers containing residual HDI may be found under a wide variety of trade names.

POTENTIAL EXPOSURE

USES: Used in leather finishing, polyurethane foams, paints, lacquers and other surface coatings.

Note: Pure HDI monomer is rarely used, but HDI is present as a residual monomer in some polymeric isocyanates.

OCCUPATION(S):

Airplane manufacturers
Autobody repair workers
Automotive workers
Contact lens makers
Diisocyanate manufacturers
Leather workers
Makers of medical supplies
Painters
Paint and varnish makers
Plastic molders
Polyurethane foam applicators
Polyurethane manufacturers
Rubber workers
Upholstery workers
Wire coating workers

LEAKS, SPILLS AND DISPOSAL

Prepare a plan in advance for handling emergencies. Keep neutralizing chemicals readily accessible.

All spills and leaks must receive prompt attention.

For major spills, evacuate non-essential personnel. Adequately ventilate. Eliminate all sources of ignition. Notify the Ministry of the Environment (MOE) of major spills.

Cover spills with solid decontaminant and allow to react for ten minutes. Commercial spill clean-up kits or pre-mixture of sorbent and neutralizing chemicals may be used (see below). Remove solid decontaminant and clean surfaces with neutralizing solution (see below). Do not use dry brooms or compressed air to clean contaminated surfaces.

Place used sorbent and other waste material in containers in an isolated location. Do not seal container until neutralizing reaction is complete (up to 24 hours) because of possible pressure build-up. Disposal must be in accordance with MOE requirements.

Suitable protective equipment and respirators must be worn during clean-up.

NEUTRALIZING CHEMICALS: Commercial neutralizing preparations are available.

A solid decontaminant may be prepared from 60 parts by weight Fuller's earth, sawdust, or vermiculite, 25 parts by weight 30% ammonia, and 15 parts by weight isopropyl alcohol.

Liquid decontaminant solution may be prepared from 8 parts water, 1 part isopropyl alcohol, and 1 part ammonia.

Decontaminant mixtures should not be used on heated surfaces.

EXPOSURE LIMITS

TWAE: Worker exposure to airborne HDI shall be reduced to the lowest practical level and in any case shall not exceed a TWA of 0.005 ppm or 0.2 μmol HDI per m^3 of air.

MAXIMUM EXPOSURE: 0.02 ppm, 0.8 μmol/m^3

PROPERTIES

FORMULA: $OCN(CH_2)_6NCO$

DESCRIPTION: Colourless to light tan liquid

ODOUR: Sharp, pungent

Odour Threshold: Greater than maximum exposure concentration

SPECIFIC GRAVITY (25°C/15.5°C): 1.05

VAPOUR DENSITY (Air = 1): 5.8

BOILING POINT: 213°C

VAPOUR PRESSURE (25°C): 0.05 mm Hg

FIRE AND EXPLOSION

HDI is a combustible liquid. Moderate risk of fire or explosion when exposed to heat or flame. Base-catalyzed reactions of HDI and materials containing active hydrogens (water, alcohols, amines, ammonia) may proceed with explosive violence.

Note - While HDI itself is not highly combustible, polymeric isocyanates containing residual HDI may also contain flammable solvents.

EXTINGUISHING MEDIA: Carbon dioxide, dry chemical or high expansion foam. Caution: reaction between HDI and foam can be vigorous.

FLASH POINT: 140°C (Cleveland open cup)

HAZARDOUS DECOMPOSITION PRODUCTS: When heated or burned, materials containing HDI can give off isocyanate vapours, carbon monoxide, carbon dioxide, oxides of nitrogen and hydrogen cyanide.

STORAGE

Store in a cool, dry, well-ventilated area away from sources of combustion, acids, bases, amines, and alcohols. Tanks and drums should be made from good quality carbon steel, protected from heat and physical damage and inspected for leaks and damage regularly. Note: Contaminated containers of HDI should be vented; otherwise build-up of gases from chemical reaction may cause container to rupture. Drums should be grounded and solidly supported.

INCOMPATIBLE WITH: Base-catalyzed reactions of HDI with alcohols in the absence of solvents can occur with explosive violence. Such reactions should generally be carried out in the presence of inert solvents. Base-catalyzed reactions with amines, ammonia and water can also proceed with explosive violence. HDI reacts slowly with water to give off carbon dioxide. HDI which has been contaminated with water must never be stored in a sealed container as the carbon dioxide formed by the reaction may cause the container to explode.

LABELLING MUST BE ADEQUATE: Sufficient to identify the major safety hazards and consistent with provincial Dangerous Goods Transportation Act requirements.

*ISOCYANATES ARE DESIGNATED SUBSTANCES UNDER ONTARIO REGULATION 455/85

HEXAMETHYLENE DIISOCYANATE

(cont'd.)

HEXAMETHYLENE DIISOCYANATE
CAS. REG. NO. 822-06-0

SAFETY PRACTICES

PRECAUTIONS:

Do not smoke or eat in areas of use.

Reduce exposure to the lowest practical level.

Inform workers of the irritant and allergenic properties of HDI.

Change non-impervious, HDI-contaminated clothing immediately and either discard or clean before re-use.

Clean all contaminated impervious clothing before re-use.

Provide safety showers and eye wash fountains in all areas of use.

VENTILATION:

Enclose operations or process equipment wherever possible.

Provide adequate general or local ventilation in all areas of use.

REPAIRS AND MAINTENANCE:

Wear suitable protective clothing and respiratory equipment (see safety equipment section).

Use proper measures and procedures before entering a confined space.

SAFETY EQUIPMENT

Coveralls, gloves and shoe coverings impervious to HDI should be worn where physical contact is possible. Natural rubber or PVC should provide adequate protection. Where splashes may occur, full face shield should be worn if respirator is not used.

RESPIRATORS:

CONC. (Isocyanate vapour & particulates)	TYPE
Less than or equal to 0.25 ppm or 10 µmol/m^3	Positive pressure supplied-air respirator with full face-piece or hood or self-contained breathing apparatus with full face-piece.
Greater than 0.25 ppm or 10 µmol/m^3	A NIOSH Type C supplied-air respirator operated in pressure demand or other positive pressure or continuous flow mode or self-contained breathing apparatus with a full face-piece operated in pressure demand mode.
Escape	Any escape self-contained breathing apparatus with full face-piece operated in pressure demand mode.

NOTES: 1. Respirators must not be a substitute for engineering controls (e.g., adequate ventilation).

2. Supplied-air respirator does not include a powered air purifying respirator.

3. Respirators need not be worn if the levels of isocyanates in air are less than the TWAE of 0.005 ppm.

HEALTH EFFECTS - PROTECTION - FIRST AID

EXPOSURE	SYMPTOMS	PROTECTION	FIRST AID
EYES:	Severe irritation, reddening	Chemical goggles or full face-piece respirator. Eye wash facilities available	Immediately flush with water for at least 15 minutes. Contact physician.
SKIN:	Severe irritation, sensitization	Gloves, protective clothing (see safety equipment section)	Flush thoroughly with water, wipe with rubbing alcohol if available, and wash with soap and water. If swelling or reddening occurs, contact physician.
INHALATION:	Severe irritation of upper respiratory tract. At high concentrations, fluid in the lungs. May be fatal.	Local exhaust ventilation, respirators (see safety equipment section)	Remove to fresh air. Apply artificial respiration if necessary. Contact physician.
INGESTION:	May cause irritation of the mouth, stomach and digestive tract.	Do not allow smoking, drinking or eating in work areas. Workers should wash thoroughly before all breaks.	If victim is conscious, give water to drink. Then give activated charcoal in water slurry (1 g activated charcoal per kg body weight). Contact physician.

LONG TERM: Recent evidence indicates that isocyanate exposure may result in decreased lung function without other symptoms. Respiratory sensitization, beginning with cold or flu-like symptoms and progressing to asthma is possible. Asthmatic reactions in persons sensitized to other isocyanates are also possible. A flu-like reaction with malaise, cough, muscle aches, fever, reduced lung function and shortness of breath has also been seen in workers exposed to HDI-based paints.

Note: Where an isocyanate control program exists medical surveillance of isocyanate-exposed workers is required. Details of medical surveillance requirements are given in the Code for Medical Surveillance of Isocyanate Exposed Workers appended to the Regulation respecting Isocyanates.

ADDITIONAL INFORMATION

This data sheet is intended to impart basic information only. If additional information or specific references concerning hexamethylene diisocyanate are required contact your local field office of the Occupational Health Branch.

06/87

ISOPHORONE DIISOCYANATE

DATA SHEET FOR INSPECTORS

ISOPHORONE DIISOCYANATE*

CAS. REG. NO. 4098-71-9

OTHER NAMES

IPDI

3-Isocyanatomethyl-3,5,5-trimethylcyclohexylisocyanate

TRADE NAMES

IPDI-T-1890

Note: Isocyanate prepolymers containing residual IPDI may be found under a variety of trade names.

POTENTIAL EXPOSURE

USES: Polyurethane paints and varnishes, elastomers, textile coatings, leather finishing.

Note: Pure IPDI monomer is rarely used but IPDI is present as a residual monomer in some polymeric isocyanates.

OCCUPATIONS:

Polyurethane paint, varnish and coating manufacturers

Polyurethane paint, varnish and coating sprayers

Leather workers

Textile processors

Plastic manufacturers and processors

LEAKS, SPILLS AND DISPOSAL

Prepare a plan in advance for handling emergencies. Keep neutralizing chemicals readily accessible.

All spills and leaks must receive prompt attention.

For major spills, evacuate non-essential personnel. Adequately ventilate. Eliminate all sources of ignition. Notify the Ministry of the Environment (MOE) of major spills.

Cover spills with solid decontaminant and allow to react for ten minutes. Commercial spill clean-up kits or pre-mixture of sorbent and neutralizing chemicals may be used. Remove solid decontaminant and clean surfaces with neutralizing solution (see below). Do not use dry brooms or compressed air to clean contaminated surfaces.

Place used sorbent and other waste material in containers in isolated location. Do not seal container until neutralizing reaction is complete (up to 24 hours) because of possible pressure build-up. Disposal must be in accordance with MOE requirements.

Suitable protective equipment and respirators must be worn during clean-up.

NEUTRALIZING CHEMICALS: Commercial neutralizing preparations are available.

A solid decontaminant may be prepared from 60 parts by weight Fuller's earth, sawdust, or vermiculite, 25 parts by weight 30% ammonia, and 15 parts by weight isopropyl alcohol.

Liquid decontaminant solution may be prepared from 8 parts water, 1 part isopropyl alcohol, and 1 part ammonia.

Decontaminant mixtures should not be used on heated surfaces.

EXPOSURE LIMITS

TWAE: Worker exposure to airborne IPDI shall be reduced to the lowest practical level and in any case shall not exceed a TWA of 0.005 ppm or 0.2 μmol IPDI per m^3 of air.

MAXIMUM EXPOSURE: 0.02 ppm, 0.8 $\mu mol/m^3$

PROPERTIES

FORMULA: $C_{12}H_{18}N_2O_2$

DESCRIPTION: Colourless to yellow liquid

ODOUR: Sharp, pungent

Odour Threshold: Greater than maximum exposure concentration

SPECIFIC GRAVITY (20°/20°C): 1.06

VAPOUR DENSITY (Air = 1): 7.67

BOILING POINT (10 mm Hg): 158°C

MELTING POINT: -60°C

VAPOUR PRESSURE (20°C): 0.0003 mm Hg

SOLUBILITY: Soluble in aromatic and aliphatic hydrocarbons, ketones, ethers.

FIRE AND EXPLOSION

In the presence of fire or high heat, will burn and release hazardous gases. May react violently with water, alcohols, amines, acids or bases.

Note: While IPDI itself is not highly combustible, polymeric isocyanates containing residual IPDI may also contain flammable solvents.

EXTINGUISHING MEDIA: Dry chemical powder, carbon dioxide

FLASH POINT (open cup): 163°C

AUTO-IGNITION TEMPERATURE: 430°C

HAZARDOUS DECOMPOSITION PRODUCTS: When heated or burned, IPDI gives off isocyanate vapours, carbon monoxide, carbon dioxide, oxides of nitrogen, and hydrogen cyanide.

STORAGE

Store in a cool, dry, well-ventilated area away from sources of combustion, acids, bases, amines, and alcohols. Tanks and drums should be made from good quality carbon steel, protected from heat and physical damage and inspected for leaks and damage regularly. Note: Contaminated containers of IPDI should be vented; otherwise build-up of gases from a chemical reaction may cause container to rupture. Drums should be grounded and solidly supported.

INCOMPATIBLE WITH: Water, alcohols, amines, mercaptans, amides, acids, bases.

LABELLING MUST BE ADEQUATE: Sufficient to identify the major safety hazards and consistent with provincial Dangerous Goods Transportation Act requirements.

*ISOCYANATES ARE DESIGNATED SUBSTANCES
ONTARIO REGULATION 455/85

ISOPHORONE DIISOCYANATE

(cont'd.)

ISOPHORONE DIISOCYANATE

CAS. REG. NO. 4098-71-9

SAFETY PRACTICES

PRECAUTIONS:

Keep containers closed as much as possible.

Keep from open flames, heat sources and contact with alcohols, acids, bases, water and other incompatible chemicals.

Do not eat, drink or smoke in areas of use.

Change work clothing immediately after use and either clean before re-use or discard.

All safety equipment must be kept clean, be regularly inspected and properly maintained.

Provide safety showers and eye wash fountains in all areas of use.

Inform workers of hazards.

VENTILATION:

Enclose operations or process equipment wherever possible.

Provide adequate local and general ventilation in all areas of use.

REPAIRS AND MAINTENANCE:

Wear suitable protective clothing and respiratory equipment.

Use proper measures and procedures before entering a confined space.

SAFETY EQUIPMENT

Coveralls, rubber or polyvinyl chloride (PVC) boots, gloves and aprons, appropriate respirator. Where splashes may occur, full face shield should be worn if respirator is not used.

RESPIRATORS:

CONC.	TYPE
Less than or equal to 0.25 ppm or 10 μmol/m^3	Positive pressure supplied-air respirator with full face-piece or hood or self-contained breathing apparatus with full face-piece.
Greater than 0.25 ppm or 10 μmol/m^3	A NIOSH Type C supplied-air respirator operated in pressure demand or other positive pressure or continuous flow mode or self-contained breathing apparatus with a full face-piece operated in pressure demand mode.
Escape	Any escape self-contained breathing apparatus with full face-piece operated in pressure demand mode.

NOTES: 1. Respirators must not be a substitute for engineering controls (e.g., adequate ventilation).

2. Supplied air respirator does not include a powered air purifying respirator.

3. Respirators need not be worn if the levels of isocyanates in air are less than the TWAE of 0.005 ppm.

HEALTH EFFECTS - PROTECTION - FIRST AID

EXPOSURE	SYMPTOMS	PROTECTION	FIRST AID
EYES:	Severe irritation, reddening	Chemical goggles or full face-piece respirator. Eye wash facilities available	Immediately flush with water for at least 15 minutes. Contact physician.
SKIN:	Severe irritation, sensitization	Gloves, protective clothing (see safety equipment section)	Flush thoroughly with water, wipe with rubbing alcohol if available, and wash with soap and water. If swelling or reddening occurs, contact physician.
INHALATION:	Severe irritation of respiratory tract, difficulty breathing. At high concentrations, fluid in the lungs.	Local exhaust ventilation, respirators (see safety equipment section)	Remove to fresh air. Apply artificial respiration if necessary. Contact physician.
INGESTION:	Sore throat, abdominal pain, diarrhea.	Do not allow smoking, drinking or eating in work areas. Workers should wash thoroughly before all breaks.	If victim is conscious, give water to drink. Then give activated charcoal in water slurry (1 g activated charcoal per kg body weight). Contact physician.

LONG TERM: Chronic exposure may result in decreased lung function without other symptoms. Respiratory sensitization, beginning with cold or flu-like symptoms and progressing to asthma is possible. Asthmatic reactions in persons sensitized to other isocyanates are also possible. A flu-like reaction with malaise, cough, muscle aches, fever, reduced lung function and shortness of breath has also been seen in workers exposed to isocyanate-based paints.

Note: Where an isocyanate control program exists medical surveillance of isocyanate-exposed workers is required. Details of medical surveillance requirements are given in the Code for Medical Surveillance of Isocyanate Exposed Workers appended to the Regulation respecting Isocyanates.

ADDITIONAL INFORMATION

This data sheet is intended to impart basic information only. If additional information or specific references concerning isophorone diisocyanate are required contact your local field office of the Occupational Health Branch.

06/87

TOLUENE DIISOCYANATE

DATA SHEET FOR INSPECTORS

TOLUENE DIISOCYANATE*

CAS. REG. NO. 584-84-9

OTHER NAMES

TDI
2,4-diisocyanate-methylbenzene
2,6-diisocyanato-methylbenzene
Isocyanic acid, 4-methyl-m-phenylene ester
Toluene 2,4-diisocyanate
Toluene 2,6-diisocyanate

TRADE NAMES

Hylene
Mondur TDS
Nacconate 100
TDI
Niax

POTENTIAL EXPOSURE

USES: Generally used to produce polyurethane foams, elastomers and coatings including paints.

OCCUPATIONES:

Adhesive workers
Insulation workers
Diisocyanate resin workers
Lacquer workers
Organic chemical synthesizers
Paint sprayers
Polyurethane makers
Refrigerator appliance workers
Rubber workers
Ship builders
Textile processors
Wire-coating workers

LEAKS, SPILLS AND DISPOSAL

Prepare a plan in advance for handling emergencies. Neutralizing chemicals should be available.

All leaks and spills must receive prompt attention.

For major spills or spills in confined areas, evacuate non-essential personnel and adequately ventilate. Notify Ministry of the Environment (MOE) of major spills.

Wear suitable respiratory equipment and protective clothing (see safety equipment section).

Clean up all spills. Minor spills may be cleaned up with wet sand, or a solution containing 50% water, 45% alcohol, 5% conc. ammonia water.

Major spills should be contained and transferred to closed containers either by pumping or after absorption on a suitable sorbent material. Spill residuals should be neutralized and clean-up with alcohol-water-ammonia solution or other proprietary neutralizing chemical.

Place contaminated materials in steel containers for disposal.

All disposal must be via MOE approved facilities.

NEUTRALIZING CHEMICALS: There are several solutions available to neutralize TDI; for further information contact the supplier.

EXPOSURE LIMITS (See section 4 of the Regulation respecting Isocyanates)

TWAE: 0.005 ppm, 0.2 micromoles/m^3 (0.035 mg/m^3)

MAXIMUM EXPOSURE CONCENTRATION: 0.02 ppm, 0.8 micromoles/m^3 (0.14 mg/m^3)

Note: 1) All necessary measures shall be taken to reduce worker exposure to TDI to the lowest practical level and in any case shall not exceed 0.02 ppm or 0.8 micromoles/m^3.

2) Details of the methods for air sampling and analysis for TDI are given in the Code for Measuring Airborne Isocyanates appended to the Regulation respecting Isocyanates.

PROPERTIES

FORMULA: $CH_3C_6H_3(NCO)_2$

DESCRIPTION: Colourless to pale yellow liquid (at normal temperatures)

ODOUR: Characteristic, pungent

Odour Threshold: 2.4 ppm in air (danger: well above maximum exposure concentration)

SPECIFIC GRAVITY (25°C): 1.22

BOILING POINT: 251°C

MELTING POINT: 8-22°C depending on isomer mixture

VAPOUR PRESSURE (25°C): 1.5 Pa

VAPOUR DENSITY (Air = 1): 6

SOLUBILITY: Soluble in aromatic hydrocarbons, nitrobenzene, acetone, ethers; reacts with water

FIRE AND EXPLOSION

TDI will burn in the presence of fire or a high heat source sufficient to cause vaporization of the liquid.

EXTINGUISHING MEDIA: Dry chemical powder extinguisher, carbon dioxide extinguisher, halons, large amounts of water or foam (reaction between TDI and water or water-based foam can be vigorous)

FLASH POINT: 135°C Cleveland Open Cup

AUTO-IGNITION: 277°C

EXPLOSIVE LIMITS (% vol. in air):
Lower 0.9% Upper 9.5%

HAZARDOUS DECOMPOSITION PRODUCTS: At high temperature or under fire conditions TDI generates irritating and hazardous vapours and toxic gases (e.g., hydrogen cyanide, phosgene and carbon monoxide).

STORAGE

Store in a cool, dry, well ventilated area away from acids, bases, amines and alcohols. Tanks and drums should be made from good quality carbon steel, protected from heat and physical damage and inspected for leaks or physical damage regularly.

INCOMPATIBLE WITH: Water, ammonia, amines, alcohols, acids and bases (decomposes with evolution of carbon dioxide).

LABELLING MUST BE ADEQUATE: Sufficient to identify the major safety hazard and should be consistent with provincial Dangerous Goods Transportation Act requirements.

*ISOCYANATES ARE DESIGNATED SUBSTANCES
ONTARIO REGULATION 455/83

TOLUENE DIISOCYANATE

(cont'd.)

TOLUENE DIISOCYANATE
CAS. REG. NO. 584-84-9

SAFETY PRACTICES

Keep containers closed as much as possible.

Keep from open flames, heat sources and contact with amines, alcohols, acids, bases and water.

Do not eat, drink, or smoke in areas of use.

Do practice good hygiene.

All safety equipment should be kept clean, be regularly inspected and properly maintained.

Remove contaminated work clothing.

VENTILATION:

Operations and processes should be enclosed wherever possible.

Adequate ventilation should be provided in all areas of use.

Respirators should be available in the area.

REPAIRS AND MAINTENANCE:

Inform workers of all potential hazards of isocyanate exposure.

Wear suitable protective clothing and respiratory equipment especially in confined spaces (see safety equipment section).

SAFETY EQUIPMENT

Safety glasses with side shields, rubber or polyvinyl chloride (PVC) boots and gloves, and heavy cotton coveralls. If splashes or aerosol contact is likely, a rubber or PVC apron should be worn in addition to an appropriate respirator.

Eye washes and chemical safety showers should be available in areas of use.

RESPIRATORS: (See subsection 4(7) of the Regulation respecting Isocyanates and the Code for Respiratory Equipment for Isocyanates appended to the Regulation).

CONC. (ppm)	TYPE
Less than or equal to 0.25 ppm	Positive pressure supplied-air respirator with full face-piece or hood or self-contained breathing apparatus with full face-piece.
Greater than 0.25 ppm	A NIOSH Type C supplied-air respirator operated in pressure demand or other positive pressure or continuous flow mode or self-contained breathing apparatus with a full face-piece operated in pressure demand.
Escape	Any escape self-contained breathing apparatus with full face-piece operated in pressure demand.

NOTES:
1. Respirators must not be a substitute for engineering controls (e.g., adequate ventilation).
2. Supplied air respirator does not include a powered air purifying respirator.

HEALTH EFFECTS - PROTECTION - FIRST AID

EXPOSURE	SYMPTOMS	PROTECTION	FIRST AID
EYES:	Irritation	Goggles, eyewash facilities available	Immediately flush with water and contact a physician.
SKIN:	Irritation	Gloves, protective clothing (see safety equipment section) Chemical safety shower	Remove contaminated clothing. Wash with warm water and soap or isopropanol.
INHALATION:	Respiratory irritation, nausea, abdominal pain, vomiting, coughing, choking occasionally a full asthmatic attack. Symptoms may occur sometime after exposure.	Enclosure, ventilation, respirator (see safety equipment section)	Remove to fresh air. Contact physician. Oxygen may be administered. If breathing has ceased apply artificial respiration.
INGESTION:	sore throat, abdominal pain, diarrhea	No food or drink in area of use; good hygiene practices	If victim is conscious, give water to drink. Then give activated charcoal in water slurry (1 g activated charcoal per kg body weight). Contact physician.

LONG TERM: Repeated exposure may lead to sensitization and/or reduced pulmonary function.

Note: Where an isocyanate control program exists medical surveillance of isocyanate exposed workers is required. Details of medical surveillance requirements are given in the Code for Medical Surveillance of Isocyanate Exposed Workers appended to the Regulation respecting Isocyanates.

ADDITIONAL INFORMATION

This data sheet is intended to impart basic information only. If additional information or specific references concerning Toluene Diisocyanate are required contact your local field office of the Occupational Health Branch.

REV. 06/87

Appendix 3 — Regulations made under the Occupational Health and Safety Act Revised Statutes of Ontario, 1980, Chapter 321 as at August 31, 1987

Acrylonitrile:	O. Reg. 733/84 as amended by O. Reg. 23/87.
Arsenic:	O. Reg. 176/86 as amended by O. Reg. 23/87.
Asbestos:	O. Reg. 570/82 as amended by O. Reg. 655/85, O. Reg. 23/87.
Asbestos on Construction Projects and in Building and Repair Operations:	O. Reg. 654/85.
Benzene:	O. Reg. 732/84 as amended by O. Reg. 23/87.
Biological or Chemical Agents, Control of Exposure to:	O. Reg. 654/86 as amended by O. Reg. 707/86, O. Reg. 339/87
Coke Oven Emissions:	O. Reg. 517/82 as amended by O. Reg. 23/87.
Construction Projects:	R.R.O. 1980, Reg. 691 as amended by O. Reg. 635/86. O. Reg. 714/82. O. Reg. 634/86.
Critical Injury Defined:	O. Reg. 156/84.
Diving Operations:	O. Reg. 146/87.
Elevated or Suspended Work Places on Building Facades:	O. Reg. 125/83.
Ethylene Oxide:	R.R.O. 1980, Reg. 692.
Fire Fighters Protective Equipment:	O. Reg. 455/83 as amended by O. Reg. 23/87.
Industrial Establishments:	O. Reg. 536/81 as amended by O. Reg. 23/87.
Isocyanates:	O. Reg. 141/82 as amended by O. Reg. 23/87.
Lead:	
Mercury:	

Appendix 3 — (cont'd)

Mines and Mining Plants:	R.R.O. 1980, Reg. 694 as amended by O. Reg. 226/83, O. Reg. 569/83, O. Reg. 365/86, O. Reg. 450/86, O. Reg. 569/86, O. Reg. 654/86, O. Reg. 258/87.
Oil and Gas-Offshore:	O. Reg. 633/86.
Silica:	O. Reg. 769/83 as amended by O. Reg. 23/87.
Teachers:	O. Reg. 191/84.
University Academics and Teaching Assistants:	O. Reg. 307/84.
Vinyl Chloride:	O. Reg. 516/82 as amended by O. Reg. 23/87.
X-Ray Safety:	O. Reg. 632/86.
Inventory of Agents or Combinations of Agents for the Purpose of Section 21 of the Act:	R.R.O. 1980, Reg. 693.

For a complete reference to the Regulations made under the Occupational Health and Safety Act, recourse should be made to the Annual Consolidated Index to the Regulations of Ontario.

Appendix 4 — Ministry of Labour District Offices

Barrie
Industrial Health and Safety
114 Worsley Street
L4M 1M1
(705) 722-6642
1-800-461-4383*

Elliot Lake
Mining Health and Safety
Algo Centre
151 Ontario Avenue
P5A 2T2
(705) 848-2885

Hamilton
119 King Street West
L8N 3Z9
Construction Health and Safety
Industrial Health and Safety
(416) 521-7736
1-800-263-6906(8)*

Kingston
1055 Princess Street, Suite 105
K7L 1H3
Construction Health and Safety
Industrial Health and Safety
(613) 545-4340
1-800-267-0915*
Mining Health and Safety
(Suite 301)
(613) 545-4335
1-800-267-0915*

Kirkland Lake
Mining Health and Safety
38 Second Street
P2N 1R1
(705) 567-5241

Kitchener
824 King Street West
N2G 1G1
Construction Health and Safety
Industrial Health and Safety
(519) 744-8101
1-800-265-2373*

London
205 Oxford Street East
N6A 5G6
Construction Health and Safety
Industrial Health and Safety
Mining Health and Safety
(519) 439-3231
1-800-265-4707*

North Bay
Industrial Health and Safety
1500 Fisher Street
Northgate Square
P1B 2H3
(705) 476-2711
1-800-461-1654*

Ottawa
2197 Riverside Drive
K1H 7X3
Construction Health and Safety
Industrial Health and Safety
(613) 523-7530
1-800-267-1916*

Peterborough
139 George Street North
K9J 3G6
Construction Health and Safety
(705) 742-3436
1-800-461-1425*
Industrial Health and Safety
(705) 876-1800
1-800-461-1425*

Richmond Hill
Mining Health and Safety
10720 Yonge Street
L4C 3C9
(416) 884-6551
1-800-268-3829*

St. Catharines
205 King Street
L2R 3J5
Construction Health and Safety
Industrial Health and Safety
(416) 682-7261
1-800-263-7260*

Sarnia
Industrial Health and Safety
700 Christina Street North
N7V 3C2
(519) 336-1200
1-800-265-1416*

Sault Ste. Marie
390 Bay Street
P6A 1X2
Construction Health and Safety
Industrial Health and Safety
(705) 949-3331
1-800-461-7268*

Sudbury
199 Larch Street
P3E 5P9
Construction Health and Safety
Industrial Health and Safety
(705) 675-4455
1-800-461-4000*
Mining Health and Safety
(705) 675-4464
1-800-461-4000*

Sudbury
260 Cedar Street
P3B 3X2
Mining Health and Safety
(Chief Engineers)
(705) 675-4468
1-800-461-4000*

Thunder Bay
435 James Street South
P7E 6E3
Construction Health and Safety
Industrial Health and Safety
(807) 475-1691
1-800-465-5016(7)*
Mining Health and Safety
(807) 475-1675
1-800-465-5016(7)*

Timmins
273 Third Avenue
P4N 1E2
Construction Health and Safety
Industrial Health and Safety
Mining Health and Safety
(705) 267-6231
Zenith 57740* (Mining)

Toronto East
2500 Lawrence Avenue East
Scarborough
M1P 2R7
Construction Health and Safety
Industrial Health and Safety
(416) 750-3557

Toronto West
2 Robert Speck Parkway
Mississauga
L4Z 1H8
Construction Health and Safety
Industrial Health and Safety
(416) 273-7800
1-800-268-2966(7)*

Windsor
500 Ouellette Avenue
Suite 305
N9A 1B3
Construction Health and Safety
Industrial Health and Safety
(519) 256-8278
1-800-265-5140(4)*

Occupational Health Branch Laboratory
101 Resources Road
Weston, Ontario
M9P 3T1
(416) 248-7261

Head Office
400 University Avenue
Toronto, Ontario
M7A 1T7

Construction Health and Safety
(416) 965-7161
1-800-268-8013*
Industrial Health and Safety
(416) 965-4125
1-800-268-8013*

Mining Health and Safety
(416) 965-1328
1-800-268-8013*
Occupational Health
(416) 965-3211
1-800-268-8013*
Special Studies and Services
(416) 965-2493
1-800-268-8013*
Standards and Programs
(416) 965-8710
1-800-268-8013*

*Toll free line. For callers located within the area code but outside the local calling area of this city. Consult the blue pages in your local telephone directory for additional information. The Ministry may also be reached 24 hours a day through the emergency telephone number in Toronto (416) 965-1211.